CLAIMS

1. An inspection system comprising:

(a) a database having stored therein a package library;

(b) an inspection plan generator coupled to receive information from said database and for generating an inspection plan;

(c) an image processing system including an image capture processor, an image processor and; and

(d) an inspection module, coupled to said image processing system, said inspection module including:

an image model processor;

a structural model processor; and

a geometric model processor.

2. The system of Claim 1 wherein said image model processor comprises:

an image model; and

means for applying the image model to an image of an object being inspected to determine if the part being inspected looks like parts that have been seen in the past.

3. The system of Claim 2 wherein the at least one attribute corresponds to one of color or luminance.

4. The system of Claim 3 wherein said image model comprises at least one attribute arranged in a fixed spatial manner.

5. The system of Claim 1 wherein said structural model processor comprises;

a structural model; and

means for applying said structural model to an image of an object being inspected to determine whether a part exists in the image that has the same structure as that encoded in said structural model.

6. The system of Claim 5 wherein said structural model comprises
a set of regions; and
a set of relations between predetermined ones of the set of regions.

7. The system of Claim 6 wherein a set of relations included in the structural model includes relative color relations between predetermined regions of the structural model.

8. The system of Claim 1 wherein said geometric model processor comprises:
a geometric model; and
means for applying the geometric model to an image of an object being inspected to determine part placement details.

9. The system of Claim 8 wherein said means for applying the geometric model to an object comprises means for searching for one or more edges or one or more gradient regions of the object with the constraint that the pattern of the one or more gradients match a top level configuration.

10. The system of Claim 9 wherein said geometric model utilizes gradients in at least one of luminance or color to precisely locate the object being inspected.

11. The system of Claim 9 wherein said means for searching includes means for simultaneously searching for one or more edges or one or more gradient regions of the object.

12. The system of Claim 1 wherein said inspection module comprises:
a learn model processor for learning and saving attributes about the appearance of parts and for generating image, structural and geometric models from data gathered and
wherein said inspection module is adapted to -update one or more of predetermined image, structural and geometric models with models generated by said learn model processor.

13. The system of Claim 1 wherein said inspection module comprises:

a background model processor for learning and saving attributes about the appearance of parts and for generating image, structural and geometric models from data gathered during an inspection process; and

wherein said inspection module is adapted to dynamically update one or more of predetermined image, structural and geometric models with models generated by said background model processor.

14. The system of Claim 13 wherein in response to a new model or set of models being learned for an object, said inspection module substitutes one or more of said new model or set of models for a corresponding model or models in the inspection plan.

15. The system of Claim 12 wherein said new model or set of models include at least one of an image model, a structural model and a geometry model for an object being inspected.

16. The system of Claim 1 further comprising a theta estimator for reducing the range of angles over which a model is applied.

17. A method for inspecting an object comprising the steps of:

(a) applying a first model having a first set of attributes to a region of interest around the object; and

(b) applying a second model to the region of interest around the object, wherein the second model has a second set of attributes wherein the second set of attributes differs from the first set of attributes by at least one attribute.

18. The method of Claim 17 further comprising the step of:

(c) applying a third model to the region of interest around the object.

19. The method of Claim 17 wherein:

the first model corresponds to one of an image model and a structural model; and

the second model corresponds to one of a structural model and a geometry model.

20. The method of Claim 17 wherein the step of applying the first model reduces the number of parameters considered by the second model.

21. The method of Claim 20 wherein the parameters are rotation and translation of the object.

22. The method of Claim 18 wherein:

the step of applying a first model comprises the step of applying an image model to the region of interest;

the step of applying a second model comprises the step of applying a structural model to the region of interest; and

the step of applying a third model comprises the step of applying a geometry model to the region of interest.

23. The method of Claim 22 wherein the step of applying an image model comprises the step of applying the image model to a region to determine if an object being inspected looks like objects on which the model has been trained.

24. The method of Claim 22 wherein the step of applying a structural model comprises the step of applying the structural model to determine whether an object exists in the region of interest that has the same structure as that encoded in the structural model.

25. The method of Claim 22 wherein the step of applying a geometry model comprises the step of applying the geometry model to precisely locate the object and to provide detailed information concerning the placement of the object.

26. The method of Claim 17 further comprising the steps of :

(d) prior to applying the first model, annotating a package library;

(e) generating an inspection plan;

(f) implementing a learning process;

(g) applying the first model to a test data set; and

(h) applying the second model to the test data set.

27. The method of Claim 26 further comprising the step of applying a third model to the test data set.

28. The method of Claim 26 wherein said learning process comprises the steps of:

selecting from a set of model types at least one model for a part type;

applying each of the at least one models to one or more placed images of the same part type;

computing a placed image score between each of the one or more selected models and each placed image in a region of interest;

applying each of the one or more models applied to the placed images of the same part type to all paste images of the same part type;

computing a paste image score between each of the one or more models and each paste image in the region of interest;

computing a separation function to provide an indication of the effectiveness of the model; and

in response to the separation function providing an indication that the model is effective, saving the model for later use.

29. A method of learning models in an inspection system, the method comprising the steps of:

(a) selecting from a set of model types at least two models for an object class;

(b) applying each of the at least two models to one or more example images which have been labeled as a true positive example;

(c) computing a positive score between each of the one or more selected models and each image labeled as a positive example;

(d) applying each of the two or more models applied in step (b) to one or more example images which have been labeled as a true negative example images;

(e) computing a negative score between each of the one or more models and each image labeled as a negative example;

(f) computing a separation function to provide an indication of the effectiveness of the model; and

(g) in response to the separation function providing an indication that the model is effective, saving the model for later use.

30. The method of Claim 29 wherein each of the at least one models includes one or more parameters, each of the one or more parameters having a value wherein the method further comprises the steps of changing at least one of the parameter values and repeating steps (b) through (g).

31. The method of Claim 29 wherein after the step of computing a negative score, the method comprises the steps of:

performing the step of checking for outlier scores; and

in response to an outlier being identified, performing the step of determining the reason for the outlier.

32. The method of Claim 29 wherein the model is at least one of:

an image model;

a structural model; or

a geometry model.

33. The method of Claim 29 wherein the method includes a plurality of models and each of the plurality of models is learned independently.

34. The method of Claim 29 wherein the method includes an image model and a structural model and the image and structural models are learned together.

35. The method of Claim 29 wherein at least one of the one or more example images represents a predetermined defect.

36. A method for updating models during an inspection of an object, the method comprising the steps of:

(a) applying a plurality of models to an image of an object being inspected to obtain a result as part of an inspection process;

(b) determining whether one or more of the models provides an unacceptable result for an object;

(c) in response to one or more of the models providing an unacceptable result, performing a debug learning process; and

(d) after completing the debug learning process, updating an inspection plan by replacing the model or set of models for the problem component with a new debugged model thereby substituting a new model for each of the one or more models in the inspection plan.

37. The method of Claim 36 wherein each of the new model or set of models for a component has been learned in a background model build step.

38. The method of Claim 36 wherein the debug learning process results in one of a revised specific model or a set of models for that part for which one or more of the models provides an unacceptable result.

39. The method of Claim 36 wherein the updated models are used in the inspection process.

40. A method of manufacturing a printed circuit board comprising the steps of:

(a) performing at least one step in a printed circuit board manufacturing process;

(b) inspecting an object on the printed circuit board by applying a first model to a region of interest around the object and applying a second different model to the same region of interest around the object;

(c) learning updated models in a background model learn process during the inspecting step, wherein the updated models can replace at least one of the first and second models used in the inspecting step.

41. The method of Claim 40 further comprising the step of:

(d) applying a third model to the region of interest around the object.

42. The method of Claim 41 wherein:

the first model corresponds to one of an image model and a structural model; and

the second model corresponds to one of a structural model and a geometry model.

43. The method of Claim 42 wherein:

the step of applying a first model comprises the step of applying an image model to the region of interest;

the step of applying a second model comprises the step of applying a structural model to the region of interest; and

the step of applying a third model comprises the step of applying a geometry model to the region of interest.

44. The method of Claim 43 wherein:

the step of applying an image model comprises the step of applying the image model to a region to determine if an object being inspected looks like objects on which the model has been trained;

the step of applying a structural model comprises the step of applying the structural model to determine whether an object exists in the region of interest that has the same structure as that encoded in the structural model; and

the step of applying a geometry model comprises the step of applying the geometry model to precisely locate the object and to provide detailed information concerning the placement of the object.

45. An inspection system comprising:

(a) an image processing system;

(b) a structural model processor adapted to cooperate with said image processing system;

(c) a geometric model processor adapted to cooperate with said image processing system; and

(d) a learn model processor, adapted to cooperate with said image processing system, said learn model processor for learning and saving attributes about the appearance of objects and for providing structural and geometric models from data gathered during an inspection process.

46. The inspection system of Claim 45 wherein said learn model processor provides structural and geometric models by updating existing structural and geometric models with attributes generated by said learn model processor.

47. The inspection system of Claim 46 wherein said structural model processor reduces the number of parameters considered by said geometric model processor.

48. The inspection system of Claim 46 wherein said learn model processor evaluates a plurality of values for a plurality of parameters in each of a structural model and a geometric model and said learn model processor determines which set of values provides an acceptable separation function.